TITLE: BOOM SYSTEM FOR WATER FILTRATION IN SHALLOW WATER

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BOOM SYSTEM FOR WATER FILTRATION IN SHALLOW WATER

This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/459,824 filed April 1, 2003, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Containment/exclusion booms can be used to filter water or to restrict the flow of debris and contaminants from one side of the boom to the other. Such contaminants can include any debris or marine or aquatic life, as well as silt, which may be contaminated with heavy metals, hydrocarbons, or laden with bacteria. Unfortunately, the filtration area available for boom curtain placement in some bodies of water is not adequate to hold a curtain the size of which would be required for the desired level of filtering. It would be desirable, therefore, to develop a boom system that is capable of overcoming this problem and affording filtration and/or exclusion capabilities in waters where existing boom systems cannot do so.

The present invention overcomes these and other deficiencies in the art.

SUMMARY OF THE INVENTION

A first aspect of the invention relates to a containment/exclusion boom that includes: a boom curtain containing an upper curtain portion and a lower curtain portion that are connected together at a central region, the upper and lower curtain portions each being formed of a sheet of flexible fabric material that allows the flow of water therethrough; first and second support systems which can be positioned in a body of water and connected separately to distinct positions on the boom curtain; whereby the first and second support systems maintain at least one of the upper and lower curtain portions in a substantially sloped arrangement upon introduction of the boom into the body of water.

A second aspect of the invention relates to a method of filtering water in a body of water that includes: providing a containment/exclusion boom of the present invention in a body of water substantially surrounding a water intake located

within the body of water; and removing water from the body of water via the water intake, whereby water passes through the curtain of the containment/exclusion boom before said removing.

The boom curtain of the present invention allows the use of containment/exclusion booms in environments where water filtration via traditional boom systems would not otherwise be available because the surface area over which filtration can occur would otherwise be insufficient. By expanding the surface area over which filtration occurs through the use of a boom curtain of the present invention, it becomes possible to install and utilize boom systems for filtration of water entering an intake system. This is of significant importance in various industries that employ water-cooling systems, which will be able to utilize the boom system of the present invention to comply with governmental regulations (regarding exclusion of aquatic biota) rather than installing expensive dry cooling towers. The boom curtains constructed with geosynthetic fabric materials allow permanent or semi-permanent installation of boom systems, which can also minimize the necessity of shutting down water intake systems for routine cleaning or maintenance.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an environmental, side elevational view of a containment/exclusion boom according to a first embodiment of the present invention.

Figure 2 is an environmental, side elevational view of a containment/exclusion boom according to a second embodiment of the present invention

DETAILED DESCRIPTION OF THE INVENTION

With reference to the figures, containment/exclusion booms of the present invention include one or more support systems, which can be positioned in a body of water, and a boom curtain connected to the one or more support systems such that the boom curtain, or at least a portion thereof, is maintained in a sloped position within the body of water, whereby the filtration surface area of the boom curtain is expanded relative to the area afforded by the water column (i.e., depth of water column x length of boom).

The boom curtain is configured to possess an upper portion and a lower portion, whereby the upper and lower portions can be positioned in a body of water such that at least one of, and more preferably both, the upper and lower portions have a sloped configuration. Upon installation in a body of water, the upper and lower portions can be configured so that they have a substantially coplanar arrangement (*see* Figure 1) or so that they are non-coplanar, i.e., such that the planes of the upper and lower portions intersect at their junction (*see* Figure 2).

Using the first embodiment as an example, a boom curtain that has a substantially co-planar arrangement and is maintained at a slope of about 45 degrees (relative to the water surface) will have a filtration surface area that is about 40 percent greater than the filtration surface area of a boom curtain that is maintained in a substantially vertical position in the same depth of water (i.e., that which is afforded by the water column). Decreasing the slope will further increase the filtration surface area, whereas increasing the slope will decrease the surface area.

However, the slope of the boom curtain or current portions (relative to the water surface) should be sufficiently large that the water current will not force the curtain or curtain portions toward the bottom of the body of water (thereby precluding filtration from those portions). Preferred slopes for the curtain or curtain portions will independently be between about 25 to about 65 degrees (relative to the water surface), more preferably between about 30 to about 60 degrees. Consequently, the filtration surface area of a boom of the present invention can be increased by between about 10 to about 135 percent, preferably about 15 to about 100 percent, relative to the filtration surface area of a boom curtain that is maintained in a substantially vertical position in the same depth of water (i.e., that which is afforded by the water column).

The boom curtain (i.e., both the upper and lower portions) is formed of one or more layers of flexible fabric material that allow the flow of water therethrough. Preferred flexible fabric materials are geosynthetic fabrics. Geosynthetic fabrics are formed of polymeric materials and can be either woven or non-woven. The geosynthetic fabric is "water-pervious" or permeable to water, meaning that water passes through the fabric and is not absorbed by the fabric.

Typically, the geosynthetic fabric can also be "oleophilic," meaning that it absorbs or attracts oil (more generally, hydrocarbons), thereby blocking the

flow of oil, but allowing water to flow therethrough. For containment of silt and other suspended particulates, it is not essential that the fabric be oleophilic.

Useful geosynthetic fabrics are further characterized by high load distribution capacity and the ability to abate material filtration. Geosynthetic fabrics are commercially available in a range of tensile strengths, permeabilities, and permitivities, and are useful for the purposes of the invention throughout those ranges. The geosynthetic fabrics are nonbiodegradable, so they do not deteriorate due to environmental exposure. During prolonged use, exposure to ultraviolet (UV) light may cause some geosynthetic fabrics to weaken or deteriorate. However, UV-resistant fabrics are commercially available as well as UV resistance treatment methods.

Geosynthetic fabric may be prepared using one or a combination of various polymers, for example polyester, polypropylene, polyamides, and polyethylene. Most commercially available geosynthetic fabrics are polypropylene or polyester. Examples of suitable nonwoven geosynthetic fabrics include, but are not limited to, AMOPAVE® 4399, AMOPAVE® HD 4597, 4545, 4553, and 4561 (all polypropylene fabrics commercially available from Amoco Fabrics and Fibers Company); Typar®, a polypropylene fabric commercially available from Dupont; TREVIRA® Spunbond, a polyester fabric commercially available from Hoechst Fibers Industries. Examples of suitable woven geosynthetic fabrics include, but are not limited to, 1380 SILT STOP®, 1198, 1199, 2090, 2000, 2006 (all polypropylene fabrics commercially available from Amoco Fabrics and Fibers Company).

For many applications, it is sufficient to construct the curtain with a single layer of geosynthetic fabric. However, for some applications a multilayer construction may be desirable to provide added strength or protection against abrasion. The layers could be of the same geosynthetic fabric or different fabrics. For instance, a curtain might have a first layer of nonwoven fabric and a second layer of a woven fabric, which would tend to be more abrasive-resistant than the nonwoven fabric. The fabric can optionally be custom designed to provide for greater or lesser water flow therethrough, as described in U.S. Patent No. 6,485,229 to Gunderson III, et al., which is hereby incorporated by reference in its entirety.

In addition, it may be desirable (for instance in turbid waters) to provide for cleaning of the boom curtain. When so desired, the boom curtain, that is one or both of the upper and lower portions thereof, are each formed of two sheets of

flexible fabric material. The upper and lower portions of the curtain can also be segmented into individual panels (i.e., at least two such panels) by stitching, heat sealing, or otherwise physically connecting the two sheets of fabric together. When a two-layered (or multi-layered) construction is employed for the curtain, the boom can also be equipped with a gas injection system which includes a source of compressed gas in fluid communication with at least one outlet positioned between the two layers of flexible fabric material. A gas injection system of this type is disclosed in U.S. Patent No. 6,485,229 to Gunderson III, et al., which is hereby incorporated by reference in its entirety. When segmented into individual panels, each panel may be equipped with its own outlet of the gas injection system. The gas injection system can be used to clean the curtain of sediments and remove aquatic organisms to prevent impingement. The bubbling action of the air rising up through the sheets of fabric layers cleans the fabric of sediment and/or aquatic life, which may be impinged thereon.

The curtain also has first and second ends that are anchored or otherwise secured to a shoreline, bulkhead, or the like. Conventional connections can be used for this purpose. Toward the ends of the curtain, the height of the curtain can appropriately taper while maintaining contact with the floor of the body of water.

Different portions of the boom curtain can be connected together using zipper connections, as disclosed in U.S. Patent Application Serial No. 10/270,798 to Dreyer (Publication No. 20030072616), which is hereby incorporated by reference in its entirety. For example, the length of the boom curtain can be prepared by using modular components that are quickly and easily zipped together to form a boom curtain that is sufficiently long for an intended use. Alternatively, different upper and lower portions can be linked together to the one or more support systems, depending upon the configuration selected for a particular installation site. Likewise, a Y-panel anchoring system, when employed, can be linked to the lower portion of the boom curtain using zipper connections when so desired.

As an alternative, sewing, marine adhesives, or heat fusion of the flexible fabric material can be used to connect multiple sheets together to add additional height, or to attach tow cords, stirrups for attaching chains or anchors lines, etc. The flexible fabric material can be sewn with a conventional industrial sewing machine, and heat fusion can be accomplished with an industrial iron. Heat fusion

can also be accomplished by puncturing or piercing through the overlapped fabric with a soldering iron. Good, strong connections have been made this way. In addition, reinforcement webbing can be sewn or heat fused to the regions of the curtain where different portions are connected together as well as over the regions which are expected to receive significant stress (i.e., where anchors or floats are tethered). The webbing can effectively minimize strain applied to those connections.

The containment boom of the invention can also include one or more tow cords secured to the curtain. The tow cords are used to tow the boom into position or from one location to another. The two cords can be bands or strips of nylon lifting straps, steel or aluminum cable, polypropylene rope, geosynthetic material, or the like that extend the length of the curtain and can be secured to the curtain or portions thereof in a manner disclosed in U.S. Patent No. 5,102,261 to Gunderson, which is hereby incorporated by reference in its entirety. Depending on the overall length of the curtain and other design parameters, additional tow cords may be positioned on the curtain or portions thereof as necessary.

The one or more support systems can be a floating support system, a permanent or semi-permanent structural installation, or a combination thereof.

Floating support systems can include a plurality of conventional flotation units usable with the present invention, such as inflatable devices, air bags, and floats made from buoyant materials, such as cork, synthetic foams, and other plastics. However, conventional devices may not perform adequately under adverse conditions. It has been found that under adverse conditions, expanded polystyrene ("EPS") is especially suitable for use as the flotation unit. It is desirable to coat or seal the EPS to prevent deterioration associated with prolonged exposure to the elements. EPS is commercially available from ARCO Chemical Company as DYLITE® and can be formed or molded into flotation units of various sizes and shapes (e.g., cylindrical, square, etc.) as required by project design. The EPS has a positive buoyancy that keeps the flotation unit substantially above the water surface at all times, allowing the flotation unit to ride the waves, even in adverse conditions. An EPS flotation unit is not deformed by wave action and does not lose buoyancy if punctured, as would an inflatable device. A single cubic foot of EPS can support as much as 60 lbs. A commonly used size of flotation unit of EPS is an 8" to 12" diameter cylindrical configuration, but the size can be readily adapted to meet specific

wave and environmental conditions and depth requirements. To accommodate the installation of flotation units into the boom curtain, the upper portion of the boom curtain can be provided with an upper sleeve that includes a series of slits along its length.

Permanent or semi-permanent support systems can include pilings of conventional construction and horizontal support members (i.e., a wire, beam, catwalk, or other like support) which extend between adjacent pilings. The boom curtain can be connected to either the horizontal support members or both the horizontal support members and the pilings. These alternative support systems are described in U.S. Patent No. 6,485,229 to Gunderson III, et al., which is hereby incorporated by reference in its entirety. The permanent or semi-permanent support system can take the form of a pier, dock, floating dock, etc.

To maintain the lower portion of the boom curtain at least substantially in contact with the floor of the body of water, an anchor or ballast of some type can be connected to the boom curtain. Typically, the ballast is a continuous length of chain or cable of sufficient weight to hold the curtain in a substantially vertical orientation below the support system.

Ballasts such as lengths of steel chain (from less than 1/8 inch to over ¾ inch) and steel cable (from less than ¾ inch to over 1 ½ inches in diameter) have been used. Of course, chains and cables of greater or less diameter may be used to meet the specific requirements of a project design. Moreover, it is not always necessary to utilize a lower sleeve (on the lower portion of the boom curtain) to contain ballast. Ballast chains, cable, or weighted cable can be tied with wire or other means to the curtain at its bottom.

In adverse wave and current conditions, the ballast alone may not be sufficient to maintain the containment boom in place or the curtain in a substantially vertical orientation. It would therefore be desirable to employ an anchor or a series of anchors to secure the boom in place. The anchors can be attached to the bottom of the curtain or to the ballast. For booms of considerable length, anchors preferably are attached at regular intervals. Anchor location may be marked by brightly colored buoys, as necessary.

The lower portion of the boom curtain can be adapted with a Y-panel or J-panel configuration in conjunction with traditional or non-traditional anchoring

systems to secure the boom in a fixed position. An exemplary form of the Y-panel anchoring system is described in U.S. Patent Application Serial No. 10/134,359 to Dreyer, (Publication No. 20020172560), which is hereby incorporated by reference in its entirety.

Referring now to Figure 1, a boom system in accordance with one embodiment of the present invention is shown therein. The boom system **10** includes a boom curtain formed of upper and lower curtain portions **12,14** respectively. Each of the upper and lower curtain portions is formed from two layers of a geosynthetic fabric material.

The upper end of the upper curtain portion **12** is formed as a sleeve **16** that receives a flotation unit **18** therein. The upper end of the upper curtain portion **12** is also tethered to structure **20**, which can be a floating dock, catwalk, or the like, by a cable **21**.

The lower end of the upper curtain portion **12** is joined to the upper end of the lower curtain portion **14** at a central region defined by seam **22**. Seam **22** is reinforced with multiple layers of nylon webbing or the like. (The seam **22** can extend the entire length of the boom curtain or simply be an intermittent series of reinforced regions.) Attached to one (lower) side of seam **22** is a tethered anchor or weight block **24** and attached to the opposite (upper) side of seam **22** is a tethered boom float **26**. Boom float **26** is preferably in the form of a sleeve **28** that contains a flotation unit **30**. The weight block **24** and the boom float **26** can be tethered using rope or steel cable or other suitable material capable of withstanding a marine environment. Together, the weight block **24** and the boom float **26** maintain the coplanar arrangement of the upper and lower curtain panels. Specifically, the upper and lower curtain panels are both maintained in a sloped arrangement given the position where their respective ends are tethered, with the planes thereof in substantial alignment.

The lower end of lower curtain portion **14** is shown provided with a Y-curtain bottom panel **32** of the type disclosed in U.S. Patent Application Serial No. 10/134,359 to Dreyer, (Publication No. 20020172560), which is hereby incorporated by reference in its entirety. A tethered anchor or weight block **34** prevents displacement of the lower end of lower curtain portion **14** against the flow of water. The weight block **34** is shown tethered with a chain, although other materials such as

steel cable can be used. A buoy **36** is tethered to the lower end of the lower curtain portion **14** to mark its location in the water.

As shown, the boom curtain is also provided with a gas injection system that includes a conduit **40** passing within sleeve **16**, that is coupled in fluid communication with infusers **42** passing through the upper and lower curtain panels. The infusers can further include lateral diffusion adapters such that air bubbles emanating therefrom can be dispersed throughout the width of the panel. Although Figure 1 is shown as a cross-section, it will be appreciated that the curtain, along its entire length, can be provided with a plurality of segmented panels (segmented in a direction from bottom to top), each including an infuser **42** coupled in fluid communication to conduit **40**. The conduit **40** is coupled in fluid communication with a source of compressed gas, such as an air compressor or tank containing compressed air. As described in U.S. Patent No. 6,485,229 to Gunderson III, et al., which is hereby incorporated by reference in its entirety, operation of the infuser can be intermittent, either automatically or following manual control.

In use, the boom system **10** will be positioned such that water preferably flows in a direction as shown in Figure 1. In this embodiment, the boom curtain is sloped at about 30 degrees relative to the surface of the water. Consequently, the height of the boom curtain (upper and lower portions together) is about twice as great as the depth of the water column. Hence the surface area of the boom curtain is about twice as great as the area afforded by the water column.

Referring now to Figure 2, a boom system in accordance with a second embodiment of the present invention is shown. The boom system **110** includes a boom curtain formed of upper and lower portions **112,114** respectively. Each of the upper and lower portions is formed from two layers of a geosynthetic fabric material.

The upper end of the upper curtain portion **112** is formed as a sleeve **116** that receives a flotation unit **118** therein. The upper end of the upper curtain portion **112** is also tethered to structure **120**, which can be a floating dock, catwalk, or the like, by a cable **121**.

The lower end of the upper curtain portion **112** is joined to the upper end of the lower curtain portion **114** at a central region defined by seam **122**. Seam **122** is reinforced with multiple layers of nylon webbing or the like. (The seam **122** can extend the entire length of the boom curtain or simply be an intermittent series of

reinforced regions.) Attached to the seam **122** is a tethered anchor or weight block **124** and a tethered boom float **126**. Boom float **126** can either be in the form or a buoy (shown) or in the form of a sleeve that contains a flotation unit (as shown in Figure 1). The weight block **124** and the boom float **126** can be tethered using rope or steel cable or other suitable material capable of withstanding a marine environment. Together, the weight block **124** and the boom float **126** maintain the non-coplanar arrangement of the upper and lower portions of the boom curtain. Specifically, the upper and lower curtain panels are both maintained in a sloped arrangement given the position where their respective ends are tethered, with the curtain having a substantially V-shaped cross-sectional configuration.

The lower end of lower curtain portion **114** is tethered to structure **120**, which prevents displacement of the lower end of lower curtain portion **14** against the flow of water. The lower curtain panel is shown tethered with a chain **131**, although other materials such as steel cable can be used. A return cable **133** is also tethered to the lower end of lower curtain portion **114**, which facilitates removal of the boom curtain from the water (when so desired).

As shown, the boom curtain is also provided with a gas injection system that includes a conduit **140** passing within sleeve **116**, that is coupled in fluid communication with infusers **142** passing through the upper and lower curtain portions. The infusers can further include lateral diffusion adapters such that air bubbles emanating therefrom can be dispersed throughout the width of the panel. Although Figure 2 is shown as a cross-section, it will be appreciated that the curtain, along its entire length, can be provided with a plurality of segmented panels, each including an infuser **142** coupled in fluid communication to conduit **140**. The conduit **140** is coupled in fluid communication with a source of compressed gas, such as an air compressor or tank containing compressed air.

In use, the boom system **110** will be positioned such that water preferably flows in a direction as shown in Figure 2. In this embodiment, both the upper and lower curtain portions have a height that is about 25 percent greater than the depth of the water column. Together, the height of the boom curtain (upper and lower portions together) is about two-and-a-half times as great as the depth of the water column. Hence the surface area of the boom curtain is about two-and-a-half times as great as the area afforded by the water column.

The boom system can be deployed from a barge, a dock with a small boat, or other surface or access point near the water. The invention is uncomplicated in design and can be easily deployed by persons having basic waterfront experience without prior training in containment boom deployment.

In use, the boom system can be deployed, e.g., about a water intake system for purposes of filtering water entering the intake system. This is achieved by introducing the boom system of the present invention into a body of water at a location that substantially separates a water intake, located on one side of the boom curtain within the body of water, from the remainder of the body of water located on the other side of the boom; and then removing water from the body of water via the water intake. As is known in the art, the position of the boom and its length (i.e., total filtration area) can be adjusted to accommodate a desired flow rate. As a result of the boom system location, water is filtered as it passes through the boom curtain and before it enters the water intake.

Although preferred embodiments have been depicted and described in detail herein, it will be apparent to those skilled in the relevant art that various modifications, additions, substitutions, and the like can be made without departing from the spirit of the invention and these are therefore considered to be within the scope of the invention as defined in the claims which follow.